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Front-end Circuit

5 The invention relates to a front-end circuit for various mobile wireless systems with frequency bands differing from one another.

The separation of the frequency bands in a front-end module for mobile communications can occur by means of, for example, circuit diodes, which constitutes a complex and costly solution.

10 To separate different frequency bands in a component with a common antenna connection, a frequency shunt (or diplexer) can be used which consists of passive circuit elements. A diplexer is usually connected in the reception path between an antenna and a plurality of receivers, one receiver being preferably provided for each frequency band.

The separation of two frequency bands in a component with a common antenna connection can occur by means of the arrangement of a low-pass filter in a first signal path and a high-pass filter in a second signal path arranged in parallel to the first signal path. A reception circuit with a band-pass filter is connected downstream in each signal path of the diplexer formed in this manner, wherein the band-pass filter must often be adjusted to the diplexer by means of an adjustment network, resulting in substantial spatial requirements.

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In known components, the diplexer must usually be connected on the input side (in the respective signal) with other components, e.g., with an adjustment network, so as to guarantee a high degree of isolation between the frequency bands. However, the

elements of the adjustment network exhibit ohmic losses and generally require a significant amount of space.

A microwave diplexer for processing a polarized signal is known from printed publication EP 0400833 B1, said diplexer having a waveguide and a plurality of band-pass resonator arrays consisting of hollow conductors disposed symmetrically around the circumference of the waveguide. This diplexer can also be used for radar applications at the highest frequencies. Because of increased spatial requirements at mobile wireless frequencies, however, this type of diplexer is not suitable for use in mobile wireless terminals.

10 The previously known front-end circuits that contain diplexers are characterized by a comparatively high insertion attenuation of the electric signal.

The goal of the present invention is to specify a front-end circuit suitable for a plurality of mobile wireless systems having various frequency bands, said circuit exhibiting a low insertion attenuation.

15 The invention specifies a front-end circuit for at least two mobile wireless systems having different frequency bands, a frequency band being allocated to each mobile wireless system. The front-end circuit has

a) a common antenna connection arranged on the input side,
b) at least two signal paths arranged in parallel and electrically connected to the
20 antenna connection, and

c) individual electric gates for each signal path, arranged on the output side, said gates being connectable to secondary stage circuits. In this connection, a unique frequency band is assigned to each signal path and a band-pass filter is arranged in each

signal path. The band-pass filter essentially contains thin-layer resonators and is directly connected to the antenna connection.

Because of the high quality of the thin-layer resonators, the front-end circuit according to the invention exhibits a low insertion attenuation at high selection (e.g.,
5 better than 20 dB) between the bands. According to the invention, it is possible to implement a frequency diplexer by means of one band-pass filter per signal path in a single component that is, without a loss-producing contact point and adjustment network, thereby reducing signal losses.

The multilayer technology in which the thin-layer resonators are designed is
10 advantageous over the comparable SAW technology (SAW = Surface Acoustic Wave), in that the resonant frequency of the resonators is not determined by structures arranged horizontally adjacent to one another, but rather by the layer thicknesses, that is, by the vertical structure of a thin-layer resonator. In this connection, the layer thicknesses, which are generally greater than 10 μm , can be more effectively controlled than the
15 horizontal dimensions of the finger-like electrodes of the SAW components, which amount to approx. 1 μm at normal mobile wireless frequencies.

The thin-layer resonators are premium connected to one another in a ladder-type or lattice-type array. According to the invention, a balun can be connected in at least one of the signal paths. The balun can be connected in at least one of the signal paths between
20 the band-pass filter and the corresponding electric gate, for example.

A balun can be implemented, for example, on the basis of a plurality of thin-layer resonators stacked on top of one another and/or at least acoustically coupled with one

another. The compound thin-layer resonators can be connected to one another in such a way that they implement a filter circuit with balun functionality.

In addition to an integrated balun functionality, the circuit according to the invention can also perform other functions. In particular, an impedance transformation
5 can be implemented by means a suitable design.

In addition to thin-layer resonators, other elements, such as capacitors, inductors and lines or line segments, preferably produced during the same process step as the thin-layer resonators, can be integrated into the front-end module according to the invention. The advantage of a compact arrangement of a plurality of components in a module is that
10 feed losses and/or unwanted couplings between the components are reduced.

A front-end circuit according to the invention is characterized by a flexible design with regard to its input and/or output impedance, and is easily adjusted to customer specifications.

In contrast to previously known multiband front-end circuits suitable for the
15 transmission of electric signals in only one direction, the front-end circuit according to the invention allows for the transmission of both reception and transmission signals in a signal path, due to a high edge steepness of the transmission function.

In an advantageous variant of the invention, band-pass filters containing a plurality of thin-layer resonators are connected to form a duplexer, the corresponding
20 signal path having a reception and a transmission path. An LNA (Low Noise Amplifier) can then be connected downstream from the duplexer in the reception path and/or a power amplifier in the transmission path, the entire circuit being implemented as a modular component.

In the following, the invention is explained in detail on the basis of exemplary embodiments and the corresponding figures. Figures 2 to 4 show completely or partially different front-end circuits according to the invention.

- 5 Figure 1 shows a block diagram of a known front-end circuit (a) and exemplary
 implementations of a diplexer (b, c)
- Figure 2 shows a front-end circuit according to the invention
- Figure 3 shows a front-end circuit according to the invention with a balun
- Figure 4 shows a front-end circuit according to the invention, which is suitable for
10 the transmission of the transmission/reception signals in two frequency
 bands
- Figure 5 shows an exemplary diplexer circuit

Figure 1a shows a block diagram of a known front-end module DI (diplexer) with
15 an antenna connection ANT_{in} and two output gates $RX1_{out}$ and $RX2_{out}$ for a first and a
second signal path. Figures 1b and 1c show exemplary circuits made up of passive
elements, which implement a known diplexer.

In Figure 2, general characteristics of the invention are explained on the basis of a
block diagram of a component according to the invention.

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A front-end circuit according to the invention is depicted schematically in Figure
2. The front-end circuit consists of two band-pass filters F1 and F2 connected in parallel
and connectable directly to a common antenna.

In the advantageous exemplary embodiment shown in Figure 3, a balun BA1, BA2 is arranged in each of the signal paths of a front-end module, said balun preferably being designed in the same technology as the band-pass filter F1 and F2.

Figure 4 shows a front-end module according to the invention, which is suited for
5 the transmission of transmission/reception signals of two mobile wireless systems, e.g., GSM 900 and GSM 1800. The duplexer D1 is arranged in signal path 1 and exhibits the band-pass filters F1A and F1B shown in Figure 5 and containing a plurality of thin-layer resonators.

Each signal path 1 or 2 is divided into a reception path RX and a transmission
10 path TX, the direction of signal transmission in the two paths RX and TX being opposed. The band-pass filter F1A arranged inside the duplexer D1 in the transmission path TX is directly connected to the antenna connection ANT_{in} . The band-pass filter F1B arranged inside the duplexer D1 in the reception path RX is connected to the antenna connection via a $\lambda/4$ line. The second duplexer D2 arranged in signal path 2 is structured
15 analogously, but is designed for a different frequency band. Each of the duplexers D1 or D2 is connected directly with the antenna connection.

The transmission frequency of the reception signal of a mobile wireless system generally differs from that of the transmission signal of this mobile wireless system. For this reason, the band-pass filters F1A and F1B have somewhat different center
20 frequencies. Within the meaning of the present invention, however, the transmission and reception bands of the same mobile wireless system, which are close to one another, are viewed as a single frequency band.

An LNA (low noise amplifier) V11 (or V21) is provided in the reception path following the duplexer D1 (or D2), and is connected between the duplexer D1 (or D2) and an additional band-pass filter F11 (or F12).

A power amplifier V12 (or V22) is provided in the transmission path, and is
5 connected between the duplexer D1 (or D2) and an additional band-pass filter F12 (or F22).

In signal paths of the front-end module according to the invention, the reception path RX and/or the transmission path TX can be provided to conduct a symmetrical signal. The balun functionality can be integrated in the duplexer circuit D1 or D2, for
10 example.

In addition to the embodiments of the invention presented in the exemplary embodiments and the corresponding figures, a number of other combinations are also conceivable, which can be obtained by omitting individual components or by combining individual components of the exemplary embodiments described.